

lation angle of the waveguide light can be finely varied. Therefore, by varying the emitting positions of the light beams from the two converging grating couplers, the converged spot can be allowed to trace on the track.

According to the eight embodiment as mentioned above, in addition to the effects of the foregoing seventh embodiment, the change-over of the waveguide lights which enter the converging grating couplers and the tracking control can be executed by the SAW transducer 91. Thus, the optical head can be simplified and the number of manufacturing steps can be reduced.

Since the surface acoustic wave 92 is located between the fourth beam splitter 93 and the two converging grating couplers, the return waveguide light from the optical disc 1 is not influenced by the tracking control on the optical path after the surface acoustic wave 92. Therefore, the converging position on the third photo detector is not moved by the tracking control, so that a deterioration in photo detection signal can be prevented.

In the embodiment, although the SAW transducer has been used as both of the optical path switching means and the optical path deflecting means for tracking control, the SAW transducer can be also provided for the optical head only for the tracking control. For instance, it is also possible to form the SAW transducer for the sixth optical head 60 in the fifth embodiment or the seventh optical head 80 in the sixth embodiment and to execute the tracking control.

We claim:

- [ 1. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal by converging a light flux onto/from a recording layer through a transparent disc substrate, comprising:

(a) N optical heads, N being greater than or equal to 2, each comprising:

light emitting means;

objective lenses, whose aberrations have respectively been corrected for said N disc substrates having different thicknesses, each for converging the light flux which is emitted from the light emitting means onto the optical disc, and

a plurality of photo detecting means each for detecting the reflected light from the optical disc;

(b) N optical head moving means which are arranged below the optical disc and move the N optical heads in the radial direction of the optical disc;

(c) disc discriminating means for discriminating the thickness of the disc substrate of the loaded optical disc and for generating a discrimination signal in accordance with the result of the discrimination; and

(d) control means for selecting the optical head having the objective lens in which the occurrence of the aberration due to the disc substrate is smallest in accordance with the discrimination signal, wherein the selected optical head records, reproduces or erases the information signal onto/from the optical disc.]

[ 2. An apparatus according to claim 1, further comprising backward moving means for moving the non-selected optical heads to the outside of the optical disc for a period of time when the optical head which has been selected by the control means is recording, reproducing, or erasing the information signal.]

[ 3. An apparatus according to claim 1, wherein said disc discriminating means comprises: a cartridge for enclosing the optical disc;

a discrimination hole which is formed on the cartridge and whose opening/closing state differs in correspondence to the thickness of the disc substrate of the optical disc; and

detecting means for detecting the opening/closing state of the discrimination hole and for generating a discrimination signal.]

[4. An apparatus according to claim 2, wherein said disc discriminating means comprises:

a cartridge for enclosing the optical disc;

a discrimination hole which is formed on the cartridge and whose opening/closing state differs in correspondence to the thickness of the disc substrate of the optical disc; and

detecting means for detecting the opening/closing state of the discrimination hole and for generating a discrimination signal.]

[5. An apparatus according to claim 1, wherein numerical apertures of at least two or more of said N objective lenses differ.]

[6. An apparatus according to claim 2, wherein numerical apertures of at least two or more of said N objective lenses differ.]

[7. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal by converging a light flux onto/from a recording layer through a transparent disc substrate, comprising:

(a) an optical head having N, N being greater than or equal to 2, converging optical systems each comprising:

light emitting means,

objective lenses, whose aberrations have respectively been corrected for said N disc substrates having different thicknesses, each for converging the light flux which is emitted from the light emitting means onto the optical disc, and

a plurality of photo detecting means each for detecting the reflected light from the optical disc;

(b) optical head moving means which is arranged below the optical disc and moves the optical head in the radial direction of the optical disc;

(c) disc discriminating means for discriminating the thickness of the disc substrate of the loaded optical disc and for generating a discrimination signal in accordance with the result of the discrimination; and

(d) control means for allowing the light emitting means, which belongs to the converging optical system in which the occurrence of the aberration due to the disc substrate is smallest in accordance with the discrimination signal, to emit light, wherein the selected converging optical system records, reproduces or erases the information signal onto/from the optical disc.]

[8. An apparatus according to claim 7, wherein said disc discriminating means comprises:

a cartridge for enclosing the optical disc;

a discrimination hole which is formed on the cartridge and whose opening/closing state differs in correspondence to the thickness of the disc substrate of the optical disc; and

detecting means for detecting the opening/closing state of the discrimination hole and for generating a discrimination signal.]

[9. An apparatus according to claim 7, wherein numerical apertures of at least two or more of said N objective lenses differ.]

10. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal by converging a light flux onto/from a recording layer through a transparent disc substrate, comprising:

- (a) an optical head including:  
 light emitting means,  
 light flux dividing means which are arranged in the light flux from the emitting means and divide the emitted light flux into  $N$ ,  $N$  being greater than or equal to 2, light fluxes and deflect in different directions,  
 $N$  objective lenses, whose aberrations have respectively been corrected for said  $N$  disc substrates having different thicknesses, for respectively converging said  $N$  light fluxes onto the optical disc,  
 light flux selecting means for selecting one of the  $N$  light fluxes divided by the light flux dividing means and for allowing said light flux to pass, and  
 photo detecting means for detecting the light fluxes reflected by the optical disc;  
 (b) optical head moving means which is arranged below the optical disc and moves the optical head in the radial direction of the optical disc;  
 (c) disc discriminating means for discriminating the thickness of the disc substrate of the loaded optical disc and for generating a discrimination signal in accordance with the result of the discrimination; and  
 (d) control means for generating a control signal to the light flux selecting means in accordance with the discrimination signal and for selecting the light flux which passes through the objective lens in which the occurrence of the aberration due to the disc substrate is smallest,

wherein the optical head records, reproduces or erases the information signal onto/from the optical disc by the selected light flux.

11. An apparatus according to claim 10, wherein said disc discriminating means comprises:

- a cartridge for enclosing the optical disc;  
 a discrimination hole which is formed on the cartridge and whose opening/closing state differs in correspondence to the thickness of the disc substrate of the optical disc; and  
 detecting means for detecting the opening/closing state of the discrimination hole and for generating a discrimination signal.

12. An apparatus according to claim 10, wherein numerical apertures of at least two or more of said  $N$  objective lenses differ.

13. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal by converging a light flux onto/from a recording layer through a transparent disc substrate, comprising:

- (a) an optical head including:  
 an optical waveguide formed on a substrate,  
 $N$  light emitting means each for emitting a waveguide light into said optical waveguide,  $N$  being greater than or equal to 2,  
 $N$  converging grating couplers, whose aberrations have respectively been corrected for said  $N$  disc substrates having different thicknesses, each for emitting the waveguide light supplied from said  $N$  light emitting means to the outside of the optical waveguide and for allowing the reflected light from the optical disc to enter, and  
 $N$  photo detecting means each for detecting reflected light and for generating an information signal;

- (b) optical head moving means which is arranged below the optical disc and moves the optical head in the radial direction of the optical disc;
  - (c) selecting means for selecting the light emitting means to be allowed to emit the light from among the  $N$  emitting means;
  - (d) disc discriminating means for discriminating the thickness of the disc substrate of the loaded optical disc and for generating a discrimination signal according to the result of the discrimination; and
  - (e) control means for generating a control signal in accordance with the discrimination signal, for providing said control signal to said selecting means and for allowing the light emitting means for emitting the waveguide light into the converging grating coupler in which the occurrence of the aberration due to the disc substrate is smallest, wherein the optical head records, reproduces or erases the information signal onto/from the optical disc by the light flux from the selected light emitting means.]
- [14. An apparatus according to claim 13, wherein said disc discriminating means comprises:
- a cartridge for enclosing the optical disc;
  - a discrimination hole which is formed on the cartridge and whose opening/closing state differs in correspondence to the thickness of the disc substrate of the optical disc; and
  - detecting means for detecting the opening/closing state of the discrimination hole and for generating a discrimination signal.]
- [15. An apparatus according to claim 13, wherein numerical apertures of at least two or more of the  $N$  converging grating couplers differ.]
- [16. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal by converging a light flux onto/from a recording layer through a transparent disc substrate, comprising:
- (a) an optical head including:
    - an optical waveguide formed on a substrate,
    - light emitting means for emitting a waveguide light into said optical waveguide,
    - light flux dividing means for dividing the waveguide light emitted from the light emitting means into  $N$  divided waveguide lights,  $N$  being greater than or equal to 2,
  - said  $N$  converging grating couplers, whose aberrations have respectively been corrected for said  $N$  disc substrates having different thicknesses, each for emitting each of said  $N$  divided waveguide lights to the outside of the optical waveguide and for allowing the reflected light from the optical disc to enter, and
  - $N$  photo detecting means for respectively detecting said reflected lights from the  $N$  converging grating couplers and for generating information signals;
  - (b) optical head moving means which is arranged below the optical disc and moves the optical head in the radial direction of the optical disc;
  - (c) output switching means for selecting and outputting one of the output signals of said  $N$  photo detecting means;
  - (d) disc discriminating means for discriminating the thickness of the disc substrate of the loaded optical disc and for generating a discrimination signal in accordance with the result of the discrimination; and

(c) control means for generating a control signal to the output switching means in accordance with the discrimination signal and for selecting the photo detecting means into which the waveguide light enters from the converging grating coupler in which the occurrence of the aberration due to the disc substrate is smallest.

17. An apparatus according to claim 16, wherein said disc discriminating means comprises:

a cartridge for enclosing the optical disc;  
a discrimination hole which is formed on the cartridge and whose opening/closing state differs in correspondence to the thickness of the disc substrate of the optical disc; and

detecting means for detecting the opening/closing state of the discrimination hole and for generating a discrimination signal.

18. An apparatus according to claim 16, wherein numerical apertures of at least two or more of the N converging grating couplers differ.

19. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal by converging a light flux onto/from a recording layer through a transparent disc substrate, comprising:

(a) an optical head including:

an optical waveguide formed on a substrate,  
light emitting means for emitting a waveguide light into said optical waveguide,

optical path switching means which is arranged on an optical path of said waveguide light and switches the propagating direction of the waveguide light in N directions in accordance with a control signal, N being greater than or equal to 2,

N converging grating couplers, whose aberrations have respectively been corrected for said N disc substrates having different thicknesses and which are respectively arranged in said N propagating directions which are switched by said optical path switching means and emit the waveguide light to the outside of the optical waveguide and allow the reflected light from the optical disc to enter, and photo detecting means for detecting the reflected light and generating an information signal;

(b) optical head moving means which is arranged below the optical disc and moves the optical head in the radial direction of the optical disc;

(c) disc discriminating means for discriminating the thickness of the disc substrate of the loaded optical disc and for generating the discrimination signal in accordance with the result of the discrimination; and

(d) control means for generating a control signal to the optical path switching means in accordance with the discrimination signal and for switching the propagating direction of the waveguide light from the light emitting means to the direction of the converging grating coupler in which the occurrence of the aberration due to the disc substrate is smallest,

wherein the optical head records, reproduces or erases the information signal onto/from the optical disc by the light flux emitted from the selected converging grating coupler.

20. An apparatus according to claim 19, wherein said optical path switching means combines deflecting means for changing the propagating direction of the waveguide light by a deflection angle according to a input signal,

and wherein said apparatus comprises:

tracking error detecting means for detecting a tracking error amount of a converged spot which has been converged onto the optical disc and for generating a tracking error signal; and

tracking control means for changing the input signal to the deflecting means in accordance with said tracking error signal and for eliminating the tracking error of the converged spot.

21. An apparatus according to claim 19, wherein said disc discriminating means comprises:

a cartridge for enclosing the optical disc;

a discrimination hole which is formed on the cartridge and whose opening/closing state differs in correspondence to the thickness of the disc substrate of the optical disc; and

detecting means for detecting the opening/closing state of the discrimination hole and for generating a discrimination signal.

22. An apparatus according to claim 20, wherein said disc discrimination means comprises:

a cartridge for enclosing the optical disc;

a discrimination hole which is formed on the cartridge and whose opening/closing state differs in correspondence to the thickness of the disc substrate of the optical disc; and

detecting means for detecting the opening/closing state of the discrimination hole and for generating a discrimination signal.

23. An apparatus according to claim 19, wherein numerical apertures of at least two or more of the N converging grating couplers differ.

24. An apparatus according to claim 20, wherein numerical apertures of at least two or more of the N converging grating couplers differ.

25. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from an optical disc having at least a transparent substrate and an information layer by converging a light flux onto said information layer through said transparent substrate, comprising an optical means having one of (a) N (where  $N \geq 2$ ) different numerical apertures, (b) N different focal distances and (c) N different working distances, for converging the light flux on said information layer, wherein said

optical disc corresponds to one of N types of optical discs provided with transparent substrates having different thicknesses and said optical converging means converges said light flux by employing one of (a) a larger one of said N numerical apertures, (b) a shorter one of said focal distances and (c) a shorter one of said working distances, with respect to one of said optical discs having a thinner one of said substrates.

26. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from any selected one of N types (where  $N \geq 2$ ) of optical discs having transparent substrates of different thicknesses, each of said N optical discs having at least a transparent substrate and an information layer, by converging a light flux on said information layer through said transparent substrate, said apparatus comprising:

at least one light emitting means for emitting said light flux;

N converging means having one of (a) different numerical apertures, (b) different focal distances and (c) different working distances and performing aberration correction over a transparent substrate of a respective one of said N optical discs, each of said N converging means operating to converge said light flux on the information layer of one of the N optical discs; and

at least one photo detecting means for detecting reflected light from said optical discs,

wherein one of said converging means having (a) a larger one of said numerical apertures, (b) a shorter one of said focal distances and (c) a shorter one of said working distances, is selected for use with one of said N optical discs having a thinner one of said transparent substrates.

27. An optical recording/reproducing apparatus according to claim 26, wherein each of said N converging means is an objective lens.

28. An optical recording/reproducing apparatus according to claim 26, wherein each of said N converging means is a grating lens.

29. An optical recording/reproducing system for recording, reproducing or erasing an information signal onto/from any selected one of

N types (where  $N \geq 2$ ) of optical discs having transparent substrates of different thicknesses, each of said N optical discs having at least a transparent substrate and an information layer, by converging a light flux on said information layer through said transparent substrate, said apparatus comprising:

at least one light emitting means for emitting said light flux;

a single converging means for converging said light flux on said information layer;

at least one optical wave front transforming means, at least one of said at least one optical wave front transforming means being disposed in an optical path connecting a light source, said converging means and one of said N optical discs; and

at least one photo detecting means for detecting reflected light from said one of said N optical discs,

wherein N composite converging optical systems having one of (a) different numerical apertures, (b) different focal distances and (c) different working distances and each including said converging means and one of said N optical wave front transforming means respectively perform aberration correction over a transparent substrate of a respective one of said N optical discs, and one of said composite converging optical systems having one of (a) a larger one of said numerical apertures, (b) a shorter one of said focal distances and (c) a shorter one of said working distances, is selected for use with one of said N optical discs having a thinner one of said transparent substrates.

30. An optical recording/reproducing apparatus according to claim 29, wherein said converging means is an objective lens.

31. An optical recording/reproducing apparatus as in claim 29, wherein said converging means is a grating lens.

32. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from any selected one of N types (where  $N \geq 2$ ) of optical discs having transparent substrates of different thicknesses, each of said N optical discs having at least a transparent substrate and an information layer, by converging a light flux on said information layer



through said transparent substrate, said apparatus comprising:

(a) N (where  $N \geq 2$ ) optical heads each including: (i) a light emitting means for emitting a light flux, (ii) a converging means for converging the light flux emitted from said light emitting means onto an information layer of one of said N optical discs loaded in said apparatus and (iii) at least one photo detecting means for detecting reflected light from said one of said N optical discs;

(b) optical head moving means, adapted to be arranged on one side of an optical disc loaded in said apparatus, for moving said N optical heads in a radial direction of said optical disc loaded in said apparatus; and

(c) control means for selecting one of said N optical heads.

wherein said converging means of each of said N optical heads have one of (a) respective numerical apertures, (b) respective focal distances and (c) respective working distances and perform aberration correction over transparent substrates of respective ones of said N optical discs, one of said N optical heads provided with one of said converging means having one of (a) a larger one of said numerical apertures, (b) a shorter one of said focal distances and (c) a shorter one of said working distances, is selected for use with one of said N optical discs having a thinner one of said transparent substrates, and said one of said N optical heads selected by said control means performs a recording, reproducing or erasing operation of said information signal on an optical disc loaded in said apparatus.

33. An apparatus according to claim 32, further comprising disc discriminating means for discriminating a type of said optical disc loaded in said apparatus and for outputting a discrimination signal according to a discrimination result, and wherein said control means selects one of said N optical heads provided with one of said converging means that generates a least aberration due to the transparent substrate of the optical disc loaded in said apparatus.

34. An apparatus according to claim 33, wherein said discriminating means comprises:

a cartridge for enclosing the optical disc loaded in said apparatus;

said cartridge having a discrimination hole which has an open/closed state characteristic which differs depending on a type of said optical disc loaded in said apparatus; and

detecting means for detecting the open/closed state characteristic of said discrimination hole.

35. An apparatus according to claim 32, further comprising backward-moving means, operative when the optical head is selected by said control means, for moving ones of the optical heads not selected by said control means to outside of the selected optical disc during a recording, reproducing or erasing operation of said information signal.

36. An apparatus according to claim 32, further comprising a light emission control circuit for controlling intensity of the light flux emitted by said light emitting means; a focus control circuit for controlling a focus position of the light flux converged on the optical disc; a tracking control circuit for controlling a tracking position of the light flux converged on the optical disc; and an optical head movement control circuit for controlling said optical head moving means; at least one of said light emission control circuit, said focus control circuit, said tracking control circuit and said optical head movement control circuit being switched with respect to one of the N optical heads selected by said control means.

37. An apparatus according to claim 32, wherein the transparent substrates of said N optical discs have thicknesses which include at least one of about 0.3mm and about 1.2mm and said converging means have numeral apertures which include at least one of about 0.45 and about 0.8.

38. An optical recording/reproducing apparatus according to claim 32, wherein said converging means is an objective lens.

39. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from any one of N types (where  $N \geq 2$ ) of optical discs having transparent substrates of different thicknesses, each of said N optical discs having at least a

transparent substrate and an information layer, by converging a light flux on said information layer through said transparent substrate, said apparatus comprising:

(a) an optical head provided with N (where  $N \geq 2$ ) optical systems each including (i) light emitting means for emitting said light flux, (ii) a converging means for converging the light flux emitted from said light emitting means onto an information layer of one of said N optical discs loaded in said apparatus and (iii) photo detecting means for detecting reflected light from said one of said N optical discs;

(b) optical head moving means, adapted to be arranged on one side of an optical disc loaded in said apparatus, for moving said optical head in a direction of the optical disc loaded in said apparatus to traverse a recording track thereof; and

(c) control means for causing light emission of said light emitting means in one of said N focus optical systems,

wherein said converging means of said N optical systems have one of (a) respective numerical apertures, (b) respective focal distances and (c) respective working distances and perform aberration correction over transparent substrates of respective ones of said N optical discs, one of said N optical systems provided with one of said converging means having one of (a) a larger one of said numerical apertures, (b) a shorter one of said focal distances and (c) a shorter one of said working distances, is selected for use with one of said N optical discs having a thinner one of said transparent substrates, and the one of said focus optical systems having said light emitting means caused to emit light by said control means performs a recording, reproducing or erasing operation of said information signal on an optical disc loaded in said apparatus.

40. An apparatus according to claim 39, further comprising disc discriminating means for discriminating a type of said optical disc loaded in said apparatus and for outputting a discrimination signal according to a discrimination result, and wherein said control means causes light emission of the light emitting means of one of said focus optical systems having

the converging means that generates a least aberration due to the transparent substrate of the loaded optical disc.

41. An apparatus according to claim 40, wherein said discriminating means comprises: a cartridge for enclosing the optical disc loaded in said apparatus;

said cartridge having a discrimination hole which has an open/closed state characteristic which differs depending on a type of said optical disc loaded in said apparatus; and

detecting means for detecting the open/closed state characteristic of said discrimination hole.

42. An apparatus according to claim 39, further comprising a light emission control circuit for controlling intensity of the light flux emitted by said light emitting means; a focus control circuit for controlling a focus position of the light flux converged on the optical disc; and a tracking control circuit for controlling a tracking position of the light flux converged on the optical disc; at least one of said light emission control circuit, said focus control circuit and said tracking control circuit being switched with respect to the selected one of the N optical heads having the focus optical system having said light emitting means caused to emit light by said control means.

43. An apparatus according to claim 39, wherein the transparent substrates of said N optical discs have thicknesses which include at least one of about 0.3mm and about 1.2mm and said converging means have numeral apertures which include at least one of about 0.45 and about 0.8.

44. An apparatus according to claim 39, wherein said converging means is an objective lens.

45. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from any of N types (where  $N \geq 2$ ) of optical discs having transparent substrates of different thicknesses, each of said N optical discs having at least a transparent substrate and an information layer, by converging a light flux on said information layer through said transparent substrate, said apparatus comprising:

(a) an optical head including (i) a light emitting means for emitting a light flux, (ii) a light flux dividing means arranged in a radiation direction of said light emitting means for dividing the light flux emitted from said light emitting means into N (where  $N \geq 2$ ) light fluxes, (iii) N converging means for converging said N light fluxes onto said information layer of one of said optical discs loaded in said apparatus and (iv) at least one photo detecting means for detecting reflected light from said one of said optical discs loaded in said apparatus; and

(b) optical head moving means, adapted to be arranged on one side of said optical disc loaded in said apparatus, for moving said optical head relative to the optical disc loaded in said apparatus to traverse a recording track thereof;

wherein said N converging means have one of (a) respective numerical apertures, (b) respective focal distances and (c) respective working distances and perform aberration correction over transparent substrates of respective ones of said N optical discs, one of said converging means having one of (a) a larger one of said numerical apertures, (b) a shorter one of said focal distances and (c) a shorter one of said working distances, is selected for use with one of said N optical discs having a thinner one of said transparent substrates, and said optical head performs a recording, reproducing or erasing operation of said information signal on said optical disc loaded in said apparatus.

46. An apparatus according to claim 45, further comprising light flux selecting means for selecting and passing one of the N light fluxes divided by said light flux dividing means according to a control signal and control means for outputting said control signal to said light flux selecting means to select the light flux to be passed through one of the N converging means.

47. An apparatus according to claim 46, further comprising disc discriminating means for discriminating a type of said optical disc loaded in said apparatus and for outputting a discrimination signal according to a discrimination result, and wherein said control means selects one of the light fluxes according to said discrimination signal to be passed through one of the converging means that generates a

least aberration due to the transparent substrate of the optical disc loaded in said apparatus.

48. An apparatus according to claim 47, wherein said discriminating means comprises: a cartridge for enclosing the optical disc loaded in said apparatus;

said cartridge having a discrimination hole which has an open/closed state characteristic which differs depending on a type of said optical disc loaded in said apparatus; and

detecting means for detecting the open/closed state characteristic of said discrimination hole.

49. An apparatus according to claim 45, wherein the transparent substrates of said N optical discs have thicknesses which include at least one of about 0.3mm and about 1.2mm and said converging means have numeral apertures which include at least one of about 0.45 and about 0.8.

50. An optical recording/reproducing apparatus according to claim 45, wherein said converging means is an objective lens.

51. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from any one of N types (where  $N \geq 2$ ) of optical discs having transparent substrates of different thicknesses, each of said N optical discs having at least a transparent substrate and an information layer, by converging a light flux on said information layer through said transparent substrate, said apparatus comprising:

(a) an optical head including (i) light emitting means for emitting said light flux, (ii) a converging means for converging said light flux onto said information layer, (iii) N (where  $N \geq 2$ ) optical wave front transforming means, and (iv) at least one photo detecting means for detecting reflected light from the optical disc; and

(b) optical head moving means, adapted to be arranged on one side of an optical disc loaded in said apparatus, for moving said optical head relative to the optical disc loaded in said apparatus to traverse a recording track thereof;

wherein a plurality of converging optical systems comprising at least one of (i) said converging means and (ii) said N optical wave front transforming means have one of (a)

respective numerical apertures, (b) respective focal distances and (c) respective working distances and perform aberration correction over respective transparent substrates of said N optical discs, one of said converging optical systems having one of (a) a larger one of said numerical apertures, (b) a shorter one of said focal distances and (c) a shorter one of said working distances is selected for one of said N optical discs having a thinner one of said transparent substrates, and said selected converging optical system performs a recording, reproducing or erasing operation of said information signal on said optical disc loaded in said apparatus.

52. An apparatus according to claim 51, wherein said optical head further includes holding means for holding said N optical wave front transforming means and for, responsive to a control signal, placing a selected one of said N optical wave front transforming means in an optical path between said light emitting means and said objective lens and control means for outputting said control signal to said holding means to place said selected one of said N optical wave front transforming means in the optical path between said light emitting means and said converging means.

53. An apparatus according to claim 51, further comprising disc discriminating means for discriminating a type of said optical disc loaded in said apparatus and for outputting a discrimination signal according to a discrimination result, and wherein said control means selects one of the light fluxes according to said discrimination signal to be passed through one of the converging optical systems that generates a least aberration due to the transparent substrate of the optical disc loaded in said apparatus.

54. An apparatus according to claim 53, wherein said discriminating means comprises: a cartridge for enclosing the optical disc loaded in said apparatus;

said cartridge having a discrimination hole which has an open/closed state characteristic which differs depending on a type of said optical disc loaded in said apparatus; and

detecting means for detecting the open/closed state characteristic of said discrimination hole.

55. An apparatus according to claim 51, wherein the transparent substrates of said N optical discs have thicknesses which include at least one of about 0.3mm and about 1.2mm and said converging optical systems have disc side numerical apertures which include at least one of about 0.45 and about 0.8.

56. An optical recording/reproducing apparatus according to claim 51, wherein said converging means is an objective lens.

57. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from any one of N types (where  $N \geq 2$ ) of optical discs having transparent substrates of different thicknesses, each of said optical discs having at least a transparent substrate and an information layer, by converging a light flux on said information layer through said transparent substrate, said apparatus comprising:

(a) an optical head including (i) a waveguide formed on a substrate, (ii) N (where  $N \geq 2$ ) light emitting means for directing waveguide light into said waveguide, (iii) N converging grating couplers for directing the waveguide light received from said N light emitting means to outside of said waveguide and for receiving reflected light from an optical disc loaded in said apparatus and (iv) N photo detecting means for detecting said reflected light through said converging grating couplers and for outputting the detected light as said information signal;

(b) an optical head moving means, adapted to be arranged on one side of the optical disc loaded in said apparatus, for moving said optical head in a radial direction of the optical disc loaded in said apparatus; and

(c) control means for providing a control signal to select one of said N light emitting means to emit light,

wherein said N converging grating couplers have one of (a) respective numerical apertures, (b) respective focal distances and (c) respective working distances and perform aberration correction over transparent substrates



of respective ones of said N optical discs, one of said converging grating couplers having one of (a) a larger one of said numerical apertures, (b) a shorter one of said focal distances and (c) a shorter one of said working distances, is selected for use with one of said N optical discs having a thinner one of said transparent substrates, and the light flux emitted from said selected light emitting means causes said optical head to perform a recording, reproducing or erasing operation of said information signal on said optical disc loaded in said apparatus.

58. An apparatus according to claim 57, further comprising disc discriminating means for discriminating a type of said optical disc loaded in said apparatus and for outputting a discrimination signal according to a discrimination result, and wherein said control means causes light emission of the light emitting means of one of said converging grating couplers that generates a least aberration due to the transparent substrate of the optical disc loaded in said apparatus.

59. An apparatus according to claim 58, wherein said discriminating means comprises: a cartridge for enclosing the optical disc loaded in said apparatus;

said cartridge having a discrimination hole which has an open/closed state characteristic which differs depending on a type of said optical disc loaded in said apparatus; and

detecting means for detecting the open/closed state characteristic of said discrimination hole.

60. An apparatus according to claim 57, further comprising a light emission control circuit for controlling intensity of the light flux emitted by said light emitting means, said light emission control circuit being switched with respect to the selected one of the N converging grating couplers.

61. An apparatus according to claim 57, wherein the transparent substrates of said N optical discs have thicknesses which include at least one of about 0.3mm and about 1.2mm and said converging grating couplers have numerical apertures which include at least one of about 0.45 and about 0.8.

62. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from any one of N types (where  $N \geq 2$ ) of optical discs having transparent substrates of different thicknesses, each of said N optical discs having at least a transparent substrate and an information layer, by converging a light flux on said information layer through said transparent substrate, said apparatus comprising:

(a) an optical head including (i) a waveguide formed on a substrate, (ii) light emitting means for directing waveguide light into said waveguide, (iii) light flux branching means for branching the waveguide light received from said light emitting means into N (where  $N \geq 2$ ) branch waveguide lights, (iv) N converging grating couplers for directing said N branch waveguide lights to outside of said waveguide and also for receiving reflected light from the optical disc loaded in said apparatus and (v) N photo detecting means for detecting said reflected light through said N converging grating couplers and for outputting the detected light as said information signal;

(b) an optical head moving means, adapted to be arranged on one side of the optical disc loaded in said apparatus, for moving said optical head in a radial direction of the optical disc loaded in said apparatus; and

(c) control means for providing a control signal to select and output one of the output signals of said N photo detecting means,

wherein said N converging grating couplers have one of (a) respective numerical apertures, (b) respective focal distances and (c) respective working distances and perform aberration correction over transparent substrates of respective ones of said N optical discs, one of said converging grating couplers having one of (a) a larger one of said numerical apertures, (b) a shorter one of said focal distances and (c) a shorter one of said working distances, is selected for use with one of said N optical discs having a thinner one of said transparent substrates, and said optical head performs a recording, reproducing or erasing operation of said information signal on said optical disc loaded in said apparatus.

63. An apparatus according to claim 62, further comprising disc discriminating means for discriminating a type of said optical disc loaded in said apparatus and for outputting a discrimination signal according to a discrimination result, and wherein said control means selects one of the output signals of said photo detecting means for detecting the reflected light returned through the converging grating coupler that generates a least aberration due to the transparent substrate of the optical disc loaded in said apparatus.

64. An apparatus according to claim 63, wherein said discriminating means comprises: a cartridge for enclosing the optical disc loaded in said apparatus;

said cartridge having a discrimination hole which has an open/closed state characteristic which differs depending on the type of said optical disc loaded in said apparatus; and detecting means for detecting the open/closed state characteristic of said discrimination hole.

65. An apparatus according to claim 62, wherein the transparent substrates of said N optical discs have thicknesses which include at least one of about 0.3mm and about 1.2mm and said converging grating couplers have numeral apertures which include at least one of about 0.45 and about 0.8.

66. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from any one of N types (where  $N \geq 2$ ) of optical discs having transparent substrates of different thicknesses, each of said N optical discs having at least a transparent substrate and an information layer, by converging a light flux on said information layer through said transparent substrate, said apparatus comprising:

(a) an optical head including (i) a waveguide formed on a substrate, (ii) light emitting means for directing waveguide light into said waveguide, (iii) optical path switching means arranged in an optical path of said waveguide light for switching a propagation direction of said waveguide light according to a control signal to N (where  $N \geq 2$ ) propagation directions, (iv) N (where  $N \geq 2$ ) converging grating couplers.

arranged in the N propagation directions switched by said optical path switching means, for directing waveguide lights traveling in said N propagation directions to outside of said waveguide and for receiving reflected light from the optical disc loaded in said apparatus and (v) photo detecting means for detecting said reflected light through said converging grating couplers and for outputting the reflected light as said information signal; and

(b) an optical head moving means, adapted to be arranged on one side of the optical disc loaded in said apparatus, for moving said optical head in a radial direction of the optical disc loaded in said apparatus,

wherein said N converging grating couplers have one of (a) respective numerical apertures, (b) respective focal distances and (c) respective working distances and perform aberration correction over transparent substrates of respective ones of said N optical discs, one of said N converging grating couplers having one of (a) a larger one of said numerical apertures, (b) a shorter one of said focal distances and (c) a shorter one of said working distances, is selected for use with one of said N optical discs having a thinner one of said transparent substrates, and said optical head performs a recording, reproducing or erasing operation of said information signal on said optical disc loaded in said apparatus.

67. An apparatus according to claim 66, wherein the transparent substrates of said N optical discs have thicknesses which include at least one of about 0.3mm and about 1.2mm and said converging grating couplers have numeral apertures which include at least one of about 0.45 and about 0.8.

68. An apparatus according to claim 66, further comprising disc discriminating means for discriminating a type of said optical disc loaded in said apparatus and for outputting a discrimination signal according to a discrimination result, and control means for outputting said control signal to said optical path switching means in response to said discrimination signal to switch the propagation direction of the waveguide light from the light emitting means to a direction of one of said

converging grating couplers that generates a least aberration due to the transparent substrate of the optical disc loaded in said apparatus.

69. An apparatus according to claim 68, wherein said discriminating means comprises: a cartridge for enclosing the optical disc loaded in said apparatus;

said cartridge having a discrimination hole which has an open/closed state characteristic which differs depending on the type of said optical disc loaded in said apparatus; and detecting means for detecting the open/closed state characteristic of said discrimination hole.

70. An apparatus according to claim 66, wherein said optical path switching means includes deflecting means for changing the propagation direction of the waveguide light by a deflection angle corresponding to a predetermined input signal; tracking error detecting means for detecting a tracking error quantity of a spot converged on the optical disc and for outputting said tracking error quantity as a tracking error signal; and tracking control means for changing said input signal to said deflection means according to said tracking error signal to remove a tracking error of said converged spot.

71. An apparatus according to claim 66, wherein said optical path switching means is a surface acoustic wave transducer arranged to intersect with the optical path of the waveguide light emitted from said light emitting means.

72. An optical recording/reproducing system for recording, reproducing or erasing an information signal onto/from any one of plural optical discs each having at least a transparent substrate and an information layer by converging a light flux on said information layer through said transparent substrate, said system comprising:

a plurality of optical heads;

a plurality of optical head moving means, adapted to be arranged on one side of an optical disc loaded in said apparatus in a radial direction of said optical disc on a center thereof, for moving said optical head in a direction relative to the optical disc so as to traverse a recording track thereof; and

a cartridge for enclosing any one of said optical discs and having N openings arranged in a

radial direction of an optical disc enclosed therein on the center thereof.

73. An apparatus according to claim 72, wherein said optical discs have transparent substrates of different thicknesses.

74. An apparatus according to claim 72, wherein the N openings of said cartridge are mutually independently opened and closed.

75. An apparatus according to claim 72, wherein said cartridge has a discrimination hole for providing an indication of a type of the optical disc loaded in said apparatus.

76. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from an optical disc having at least a transparent substrate and an information layer by converging a light flux on said information layer through said transparent substrate, said apparatus comprising:

at least one light emitting means for emitting a light flux;

a converging means for converging said light flux on said information layer of one of N (where  $N \geq 2$ ) optical discs loaded in said apparatus and performing aberration correction over respective transparent substrates of said N optical discs having different thicknesses; and

at least one photo detecting means for detecting reflected light from said optical disc loaded in said apparatus through said converging means and for outputting the detected reflected light as an electrical signal.

wherein the thickness of the transparent substrate of the optical disc is discriminated by said electrical signal.

77. An optical recording/reproducing apparatus according to claim 76, wherein said converging means is one of an objective lens and a grating lens.

78. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from an optical disc having at least a transparent substrate and an information layer by converging a light flux on said information layer through said transparent substrate, said apparatus comprising:

at least one light emitting means for emitting a light flux;

a single objective lens for converging said light flux on said information layer;

N (where  $N \geq 2$ ) optical wave front transforming elements one of which is arranged in an optical path between said light emitting means and said objective lens; and

at least one photo detecting means for detecting reflected light from said optical disc through said objective lens and for outputting the detected reflected light as an electrical signal,

wherein composite converging optical systems corresponding to combinations of (i) said objective lens and (ii) said N optical wave front transforming means perform aberration correction over respective transparent substrates of N optical discs having different thicknesses, and the thickness of the transparent substrate of the optical disc loaded in said apparatus is discriminated by said electrical signal.

79. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from an optical disc having at least a transparent substrate and an information layer by converging a light flux on said information layer through said transparent substrate, said apparatus comprising:

at least one light emitting means for emitting a light flux;

N grating lenses for performing aberration correction over respective transparent substrates of N (where  $N \geq 2$ ) optical discs having different thicknesses to converge said light flux on said information layer of one of said optical discs loaded in said apparatus; and

at least one photo detecting means for detecting reflected light from said optical disc loaded in said apparatus through said grating lenses and for outputting the detected reflected light as an electrical signal,

wherein the thickness of the transparent substrate of the optical disc loaded in said apparatus is discriminated by said electrical signal.

80. An optical recording/reproducing apparatus for recording, reproducing or erasing an information signal onto/from any one of N types (where  $N \geq 2$ ) of optical discs having transparent substrates of different thicknesses, each of said N optical discs having at least a

transparent substrate and an information layer, by converging a light flux on said information layer through said transparent substrate, said apparatus comprising:

(a) an optical head including (i) light emitting means for emitting said light flux, (ii) optical means for converging said light flux onto said information layer, and (iii) at least one photo detecting means for detecting reflected light from the optical disc; and

(b) optical head moving means, adapted to be arranged on one side of an optical disc loaded in said apparatus, for moving said optical head relative to the optical disc loaded in said apparatus to traverse a recording track thereof;

wherein said optical means comprises one of (a) N different numerical apertures, (b) N different focal distances and (c) N different working distances and performs aberration correction over respective transparent substrates of said N optical discs, one of (a) a larger one of said numerical apertures, (b) a shorter one of said focal distances and (c) a shorter one of said working distances is selected for one of said N optical discs having a thinner one of said transparent substrates, and said optical means performs a recording, reproducing or erasing operation of said information signal on said optical disc loaded in said apparatus.

81. An apparatus according to claim 80, further comprising disc discriminating means for discriminating a type of said optical disc loaded in said apparatus and for outputting a discrimination signal according to a discrimination result, and a control means for selecting the converged light flux, according to said discrimination signal, that generates a least aberration due to the transparent substrate of the optical disc loaded in said apparatus.

82. An apparatus according to claim 81, wherein said discriminating means comprises: a cartridge for enclosing the optical disc loaded in said apparatus;

said cartridge having a discrimination hole which has an open/closed state characteristic which differs depending on a type of said optical disc loaded in said apparatus; and



detecting means for detecting the  
open/closed state characteristic of said  
discrimination hole.

83. An apparatus according to claim 80,  
wherein the transparent substrates of said N  
optical discs have thicknesses which include at  
least one of about 0.3mm and about 1.2mm and  
said converging optical systems have disc side  
numeral apertures which include at least one of  
about 0.45 and about 0.8.

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